

- 42 -

WHAT IS CLAIMED IS:

1. A method for repairing a sample comprising:
generating a laser beam;
changing a phase of the laser beam to smooth the
5 brightness distribution of the laser beam, and applying
the laser beam to the sample;

acquiring an image of the sample with a Time Delay
Integration (TDI) sensor, and outputting an image
signal from the TDI sensor in accordance with relative
10 movement of the laser beam and the sample;

detecting a defect of the mask pattern of the
sample on the basis of the image signal output from the
TDI sensor;

specifying the position of the defect of the mask-
15 pattern on the basis of the result obtained by the
detecting step; and

repairing the defect of the mask pattern.

2. A method for repairing a sample according to
claim 1, wherein a signal integration time of the TDI
20 sensor is enough for smoothing the brightness
distribution of the laser beam in the step of changing.

3. A method for repairing a sample according to
claim 1, wherein a laser beam source used in the
generating step is a source which can continuously emit
25 a laser beam.

4. A method for repairing a sample according to
claim 1, wherein the changing step includes the step of

09670702.060101

Sub
A3

- 43 -

changing the optical axis of the laser beam against the sample continuously or intermittently to change interference fringes of the laser beam, thereby smoothing the brightness distribution of the laser beam.

5 5. A method for repairing a sample according to claim 4, wherein the period when the optical axis of the laser beam is changed against the sample is decided in accordance with the signal integration time of a Time Delay Integration (TDI) sensor.

10 6. A method for repairing a sample according to claim 1, wherein the changing step includes the step of passing the laser beam into a rotating phase shift plate which has different thickness points, to change the phase of the laser beam, thereby smoothing the
15 brightness distribution of the laser beam.

 7. A method for repairing a sample according to claim 6, wherein the rotation velocity of the phase shift plate is enough for the signal integration of the TDI sensor.

20 8. A method for repairing a sample according to claim 6, wherein the changing step includes the step of passing the laser beam into a plurality of rotating phase shift plates.

25 9. A method for repairing a sample according to claim 8, wherein the total rotation rate of the phase shift plates is enough for smoothing the brightness for the signal integration of the TDI sensor.

09650702-060101

SUB
a4SUB
a5SUB
a6

- 44 -

10. A method for repairing a sample according to claim 1, wherein the changing step includes a first step of detouring a part of the laser beam, and

5 a second step of detouring the part of the laser beam detoured in the first detouring step, in a different direction from the detour a first detouring step;

10 thereby dividing the laser beam to reduce the coherency of the laser beam and smooth the brightness distribution of the laser beam.

11. A method for repairing a sample according to claim 1, wherein the changing step includes a first step of detouring about one-half of the laser beam, and

15 a second step of detouring the half of the laser beam detoured in the first detouring step, in a direction inclined at 90 degrees against the detour direction in the first detouring step;

20 thereby dividing the laser beam into four beams which do not interfere with each other, to reduce the coherency of the laser beam and make uniform the brightness distribution of the laser beam.

25 12. A method for repairing a sample according to claim 10, wherein the path length difference between the total path length in the first detouring step and in the second detouring step and the path length of the laser beam not detoured is a coherency distance or more, thereby dividing the laser beam into four ray beams

09870702-060101

- 45 -

which do not interfere with each other.

13. A method for repairing a sample according to claim 10, further including the step of providing a half wave plate for rotating, at 90 degrees, the polarized direction of a part of the laser beam, the part including the center of the laser beam, among the laser beams which have been via the second detouring step.

14. A method for repairing a sample according to
claim 13, wherein a prism with a wedge form is provided
in the front or in the rear of the half wave plate.

15. A method for repairing a sample according to claim 1, further including the step of outputting the image signal output from the TDI sensor after
15 correcting the image signal by use of a correction coefficient associated with a line width of the mask pattern of the sample.

16. A method for repairing a sample according to claim 1, wherein in the detecting step, the image signal output from the TDI sensor is compared with reference data which is read out, to thereby detect whether or not the mask pattern has a defect.

17. A method for repairing a sample according to claim 16, further including the step of detecting a relative speed of the sample to the TDI sensor, and correcting timing at which the reference data is read out, in accordance with the relative speed.

- 46 -

18. A method for inspecting a sample, comprising:
generating a laser beam;
changing a phase of the laser beam to smooth the
brightness distribution of the laser beam;
5 applying the smoothed laser beam to the sample;
acquiring an image of the sample using a Time
Delay Integration (TDI) sensor while the laser beam and
the sample are relatively moved; and
examining the image of the sample for a defect of
10 the mask-pattern of the sample.

19. A method for inspecting a sample according to
claim 18, wherein a signal integration time of the TDI
sensor is enough for smoothing the brightness
distribution of the laser beam in the step of changing.

15 20. A method for inspecting a sample according to
claim 18, wherein the laser beam used in the generating
step is a source which can continuously emit a laser
beam.

21. A method for inspecting a sample according to
claim 18, wherein the changing step includes the step
of changing the optical axis of the laser beam against
the sample continuously or intermittently to change
interference fringes of the laser beam, thereby
smoothing the brightness distribution of the laser beam.

25 22. A method for inspecting a sample according to
claim 21, wherein the period when the optical axis of
the laser beam is changed against the sample is decided

09870702-060101
TOT090-20707860SUY
A7 20

- 47 -

in accordance with the signal integration time of the TDI sensor.

23. A method for inspecting a sample according to claim 18, wherein the changing step includes the step of passing the laser beam into a rotating phase shift plate which has different thickness points, to change the phase of the laser beam, thereby smoothing the brightness distribution of the laser beam.

24. A method for inspecting a sample according to claim 23, wherein the rotation velocity of the phase shift plate is enough for the signal integration of the TDI sensor.

25. A method for inspecting a sample according to claim 23, wherein the changing step includes the step of passing the laser beam into a plurality of rotating phase shift plates.

26. A method for inspecting a sample according to claim 25, wherein the total rotation rate of the phase shift plates is enough for smoothing the brightness for the signal integration of the TDI sensor.

27. A method for inspecting a sample according to claim 18, wherein the changing step includes a first step of detouring a part of the laser beam and

a second step of detouring the part of the laser beam detour d in the first detouring step, in a different direction from the detour of the first detouring step;

1. **Introduction**
 2. **Background**
 3. **Methodology**
 4. **Results**
 5. **Discussion**
 6. **Conclusion**
 7. **References**
 8. **Appendix**
 9. **Figure 1**
 10. **Figure 2**
 11. **Figure 3**
 12. **Figure 4**
 13. **Figure 5**
 14. **Figure 6**
 15. **Figure 7**
 16. **Figure 8**
 17. **Figure 9**
 18. **Figure 10**
 19. **Figure 11**
 20. **Figure 12**
 21. **Figure 13**
 22. **Figure 14**
 23. **Figure 15**
 24. **Figure 16**
 25. **Figure 17**
 26. **Figure 18**
 27. **Figure 19**
 28. **Figure 20**
 29. **Figure 21**
 30. **Figure 22**
 31. **Figure 23**
 32. **Figure 24**
 33. **Figure 25**
 34. **Figure 26**
 35. **Figure 27**
 36. **Figure 28**
 37. **Figure 29**
 38. **Figure 30**
 39. **Figure 31**
 40. **Figure 32**
 41. **Figure 33**
 42. **Figure 34**
 43. **Figure 35**
 44. **Figure 36**
 45. **Figure 37**
 46. **Figure 38**
 47. **Figure 39**
 48. **Figure 40**
 49. **Figure 41**
 50. **Figure 42**
 51. **Figure 43**
 52. **Figure 44**
 53. **Figure 45**
 54. **Figure 46**
 55. **Figure 47**
 56. **Figure 48**
 57. **Figure 49**
 58. **Figure 50**
 59. **Figure 51**
 60. **Figure 52**
 61. **Figure 53**
 62. **Figure 54**
 63. **Figure 55**
 64. **Figure 56**
 65. **Figure 57**
 66. **Figure 58**
 67. **Figure 59**
 68. **Figure 60**
 69. **Figure 61**
 70. **Figure 62**
 71. **Figure 63**
 72. **Figure 64**
 73. **Figure 65**
 74. **Figure 66**
 75. **Figure 67**
 76. **Figure 68**
 77. **Figure 69**
 78. **Figure 70**
 79. **Figure 71**
 80. **Figure 72**
 81. **Figure 73**
 82. **Figure 74**
 83. **Figure 75**
 84. **Figure 76**
 85. **Figure 77**
 86. **Figure 78**
 87. **Figure 79**
 88. **Figure 80**
 89. **Figure 81**
 90. **Figure 82**
 91. **Figure 83**
 92. **Figure 84**
 93. **Figure 85**
 94. **Figure 86**
 95. **Figure 87**
 96. **Figure 88**
 97. **Figure 89**
 98. **Figure 90**
 99. **Figure 91**
 100. **Figure 92**
 101. **Figure 93**
 102. **Figure 94**
 103. **Figure 95**
 104. **Figure 96**
 105. **Figure 97**
 106. **Figure 98**
 107. **Figure 99**
 108. **Figure 100**
 109. **Figure 101**
 110. **Figure 102**
 111. **Figure 103**
 112. **Figure 104**
 113. **Figure 105**
 114. **Figure 106**
 115. **Figure 107**
 116. **Figure 108**
 117. **Figure 109**
 118. **Figure 110**
 119. **Figure 111**
 120. **Figure 112**
 121. **Figure 113**
 122. **Figure 114**
 123. **Figure 115**
 124. **Figure 116**
 125. **Figure 117**
 126. **Figure 118**
 127. **Figure 119**
 128. **Figure 120**
 129. **Figure 121**
 130. **Figure 122**
 131. **Figure 123**
 132. **Figure 124**
 133. **Figure 125**
 134. **Figure 126**
 135. **Figure 127**
 136. **Figure 128**
 137. **Figure 129**
 138. **Figure 130**
 139. **Figure 131**
 140. **Figure 132**
 141. **Figure 133**
 142. **Figure 134**
 143. **Figure 135**
 144. **Figure 136**
 145. **Figure 137**
 146. **Figure 138**
 147. **Figure 139**
 148. **Figure 140**
 149. **Figure 141**
 150. **Figure 142**
 151. **Figure 143**
 152. **Figure 144**
 153. **Figure 145**
 154. **Figure 146**
 155. **Figure 147**
 156. **Figure 148**
 157. **Figure 149**
 158. **Figure 150**
 159. **Figure 151**
 160. **Figure 152**
 161. **Figure 153**
 162. **Figure 154**
 163. **Figure 155**
 164. **Figure 156**
 165. **Figure 157**
 166. **Figure 158**
 167. **Figure 159**
 168. **Figure 160**
 169. **Figure 161**
 170. **Figure 162**
 171. **Figure 163**
 172. **Figure 164**
 173. **Figure 165**
 174. **Figure 166**
 175. **Figure 167**
 176. **Figure 168**
 177. **Figure 169**
 178. **Figure 170**
 179. **Figure 171**
 180. **Figure 172**
 181. **Figure 173**
 182. **Figure 174**
 183. **Figure 175**
 184. **Figure 176**
 185. **Figure 177**
 186. **Figure 178**
 187. **Figure 179**
 188. **Figure 180**
 189. **Figure 181**
 190. **Figure 182**
 191. **Figure 183**
 192. **Figure 184**
 193. **Figure 185**
 194. **Figure 186**
 195. **Figure 187**
 196. **Figure 188**
 197. **Figure 189**
 198. **Figure 190**
 199. **Figure 191**
 200. **Figure 192**
 201. **Figure 193**
 202. **Figure 194**
 203. **Figure 195**
 204. **Figure 196**
 205. **Figure 197**
 206. **Figure 198**
 207. **Figure 199**
 208. **Figure 200**
 209. **Figure 201**
 210. **Figure 202**
 211. **Figure 203**
 212. **Figure 204**
 213. **Figure 205**
 214. **Figure 206**
 215. **Figure 207**
 216. **Figure 208**
 217. **Figure 209**

- 49 -

detouring step.

31. A method for inspecting a sample according to claim 30, wherein a prism with a wedge form is provided in the front or in the rear of the half wave plate.

5 32. A method for inspecting a sample according to claim 18, further including the step of outputting the image signal output from the TDI sensor after correcting the image signal by use of a correction coefficient associated with a line width of the mask-pattern of the sample.

10 33. A method for inspecting a sample according to claim 18, wherein in the examining step, a signal output from the TDI sensor is compared with reference data which is read, to thereby detect whether or not the mask pattern has a defect.

15 34. A method for inspecting a sample according to claim 33, further including the step of detecting a relative speed of the sample to the TDI sensor, and correcting timing at which the reference data is read, in accordance with the relative speed.

20 35. A method for manufacturing a photomask comprising:

forming a pattern onto the photomask;

generating a laser beam;

25 changing a phase of the laser beam to smooth the brightness distribution of the laser beam, and applying the smoothed laser beam to the photomask;

09870702-060404

- 50 -

acquiring an image of the photomask with a TDI sensor as the laser beam and the photomask are moved relatively;

5 acquiring a defect of the mask-pattern of the photomask on the basis of the image of the photomask; and

when the defect of the mask-pattern is detected, specifying the position of the defect of the mask pattern, and repairing the defect of the mask pattern.

10 36. A method for manufacturing a photomask according to claim 35, wherein a signal integration time of the TDI sensor is enough for smoothing the brightness distribution of the laser beam in the step of changing.

15 37. A method for manufacturing a photomask according to claim 35, wherein a laser beam source used in the generating step is a source which can continuously emit a laser beam.

38. A method for manufacturing a photomask according to claim 35, wherein the changing step includes the step of changing the optical axis of the laser beam against the sample continuously or intermittently to change interference fringes of the laser beam, thereby smoothing the brightness
25 distribution of the laser beam.

39. A method for manufacturing a photomask according to claim 38, wherein the period when the

09070702 060101

Suz
a1120

- 51 -

optical axis of the laser beam is changed against the photomask is decided in accordance with the signal integration time of a Time Delay Integration (TDI) sensor.

40. A method for manufacturing a photomask according to claim 35, wherein the changing step includes the step of passing the laser beam into a rotating phase shift plate which has different thickness points, to change the phase of the laser beam, thereby smoothing the brightness distribution of the laser beam.

41. A method for manufacturing a photomask according to claim 40, wherein the rotation velocity of the phase shift plate is enough for the signal integration of the TDI sensor.

42. A method for manufacturing a photomask according to claim 40, wherein the changing step includes the step of passing the laser beam into a plurality of rotating phase shift plates.

43. A method for manufacturing a photomask according to claim 42, wherein the total rotation rate of the phase shift plates is enough for smoothing the brightness for the signal integration of the TDI sensor.

44. A method for manufacturing a photomask according to claim 35, wherein the changing step includes a first step of detouring a part of the laser beam, and

09870702-060100

SUB
A12SUB
A13SUB
A2514

- 52 -

a second step of detouring the part of the laser beam detoured in the first detouring step, in a different direction from the detour a first detouring step;

5 thereby dividing the laser beam to reduce the coherency of the laser beam and smooth the brightness distribution of the laser beam.

45. A method for manufacturing a photomask according to claim 35, wherein the changing step
10 includes a first step of detouring about one-half of the laser beam, and

a second step of detouring the half of the laser beam detoured in the first detouring step, in a direction inclined at 90 degrees against the detour
15 direction in the first detouring step;

thereby dividing the laser beam into four beams which do not interfere with each other, to reduce the coherency of the laser beam and make uniform the brightness distribution of the laser beam.

20 46. A method for manufacturing a photomask according to claim 44, wherein the path length difference between the total path length in the first detouring step and in the second detouring step and the path length of the laser beam not detoured is a
25 coherency distance or more, thereby dividing the laser beam into four ray beams which do not interfere with each other.

09870702-060101
TOT090-20707860

- 53 -

47. A method for manufacturing a photomask according to claim 44, further including the step of providing a half wave plate for rotating, at 90 degrees, the polarized direction of a part of the laser beam, the part including the center of the laser beam, among the laser beams which have been detoured via the second detouring step.

48. A method for manufacturing a photomask according to claim 47, wherein a prism with a wedge form is provided in the front or in the rear of the half wave plate.

49. A method for manufacturing a photomask according to claim 35, further including the step of outputting the image signal output from the TDI sensor after correcting the image signal by use of a correction coefficient associated with a line width of the mask pattern of the photomask.

50. A method for manufacturing a photomask according to claim 35, wherein in the detecting step, the image signal output from the TDI sensor is compared with reference data which is read out, to thereby detect whether or not the mask pattern has a defect.

51. A method for manufacturing a photomask according to claim 50, further including the step of detecting a relative speed of the photomask to the TDI sensor, and correcting timing at which the reference data is read out, in accordance with the relative speed.

09870702 060404

- 54 -

52. A method for manufacturing a semiconductor device by using a photomask after inspecting the photomask, comprising:

generating a laser beam;

5 changing a phase of the laser beam to smooth the brightness distribution of the laser beam;

applying the smoothed laser beam to the photomask;

acquiring an image of the photomask using a Time Delay Integration (TDI) sensor while the laser beam and the photomask are relatively moved; and

10 examining the image of the photomask for a defect of the mask-pattern of the photomask.

53. A method for manufacturing a semiconductor device by using a photomask after manufacturing the photomask, comprising:

15 forming a pattern onto the photomask;

generating a laser beam;

changing a phase of the laser beam to smooth the brightness distribution of the laser beam, and applying the smoothed laser beam to the photomask;

20 acquiring an image of the photomask with a TDI sensor as the laser beam and the photomask are relatively moved;

acquiring a defect of the mask pattern of the photomask on the basis of the image of the photomask; and

25 when the defect of the mask pattern is detected,

09070702.060404

- 55 -

specifying the position of the defect of the mask pattern, and repairing the defect of the mask pattern.

54. A method for inspecting a sample, comprising:
an illumination step of irradiating a sample with a laser beam while changing a phase of the laser beam with time, thereby permitting brightness on the sample to vary with time;

an image formation step of acquiring an image of the sample, using a sensor placed on an image plane of the sample; and

an image processing step of processing signals obtained by the sensor, so as to inspect a pattern of the sample.

55. A method according to claim 54, wherein in said image formation step, an image or a brightness signal relating to a desired portion of the sample is obtained by moving an illuminating beam and the sample relative to each other, or a two-dimensional image is obtained by use of a sensor wherein elements are arranged in two dimensions.

SUB
A15

5

10

15

20

090702.060101